Tectonophysics 681 (2016) 263–277

Contents lists available at ScienceDirect

Tectonophysics

journal homepage: www.elsevier.com/locate/tecto

Paleomagnetic and geochronological study of Carboniferous forearc basin rocks in the Southern New England Orogen (Eastern Australia)

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ARTICLE INFO

Article history:
Received 1 August 2015
Received in revised form 6 December 2015
Accepted 7 January 2016
Available online 2 February 2016

Keywords:
New England oroclines
Carboniferous
Paleomagnetism
Geochronology
Gondwana
Kiaman Superchron

ABSTRACT

We present results of a paleomagnetic study from Carboniferous forearc basin rocks that occur at both limbs of the Texas Orocline (New England Orogen, eastern Australia). Using thermal and alternating field demagnetizations, two remanence components have been isolated from rocks sampled from the Emu Creek terrane, in the eastern limb of the orocline. A middle-temperature Component M is post-folding and was likely acquired during low-temperature oxidation at 65–35 Ma. A high-temperature Component H is pre-folding, but its comparison with the paleomagnetic data from coeval rocks in the northern Tamworth terrane on the other limb of Texas Orocline does not indicate rotations around a vertical axis, as expected from geological data. A likely explanation for this apparent discrepancy is that Component H postdates the oroclinal bending, but predates folding in late stages of the 265–230 Ma Hunter Bowen Orogeny. The post-Kiaman age of Component H is supported by the presence of an alternating paleomagnetic polarity in the studied rocks. A paleomagnetic study of volcanic and volcaniclastic rocks in the Boomi Creek area (northern Tamworth terrane) revealed a stable high-temperature pre-folding characteristic remanence, which is dated to c. 318 Ma using U–Pb zircon geochronology. The new paleopole (37.8°S, 182.7°E, $A_{95} = 16.2°$) is consistent with previously published poles from coeval rocks from the northern Tamworth terrane. The combination of our new paleomagnetic and geochronological data with previously published results allows us to develop a revised kinematic model of the New England Orogen from 340 Ma to 270 Ma, which compared to the previous model, incorporates a different orientation of the northern Tamworth terrane at 340 Ma.

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1. Introduction

The New England Orogen (NEO), which is the youngest segment of the Tasmanides in eastern Australian (Fig. 1), developed as an accretionary orogen during the late Paleozoic and early Mesozoic along the Pacific margin of the Gondwana supercontinent (Cawood, 2005). The orogen predominantly consists of Devonian–Carboniferous subduction related units (magmatic arc, forearc basin and accretionary complex), which are partly covered or intruded by younger sedimentary and magmatic rocks (Fig. 1b). The southern part of the NEO exhibits a doubly vergent oroclinal structure with the southern (Manning – Nambucca oroclines) and northern (Texas – Coffs Harbour oroclines) segments displaying S- and Z-shaped geometries, respectively. It is generally accepted that the oroclines formed during the Early Permian (299–270 Ma), but their geodynamic evolution is controversial (e.g., Murray et al., 1987; Korsch and Harrington, 1987; Glen, 2005; Offler and Foster, 2008; Cawood et al., 2011; Glen and Roberts, 2012; Rosenbaum, 2012a; Rosenbaum et al., 2012; Shaanan et al., 2015), particularly due to the scarcity of robust constraints on the kinematics of oroclinal bending.

The largest and most prominent curvature in NEO is the Texas Orocline (Fig. 1b). Part of the orocline is concealed beneath younger sedimentary rocks of the Surat Basin (Brooke-Barnett and Rosenbaum, 2015), but the curvature is clearly evident in aeromagnetic images (e.g., Brooke-Barnett and Rosenbaum, 2015), magnetic fabric (Aubourg et al., 2004; Mochales et al., 2014), and in the curved structural fabric of accretionary complex rocks (Lennox and Flood, 1997; Li et al., 2012). An additional independent marker of the orogenic curvature is the occurrence of Carboniferous forearc basin

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http://dx.doi.org/10.1016/j.tecto.2016.01.029
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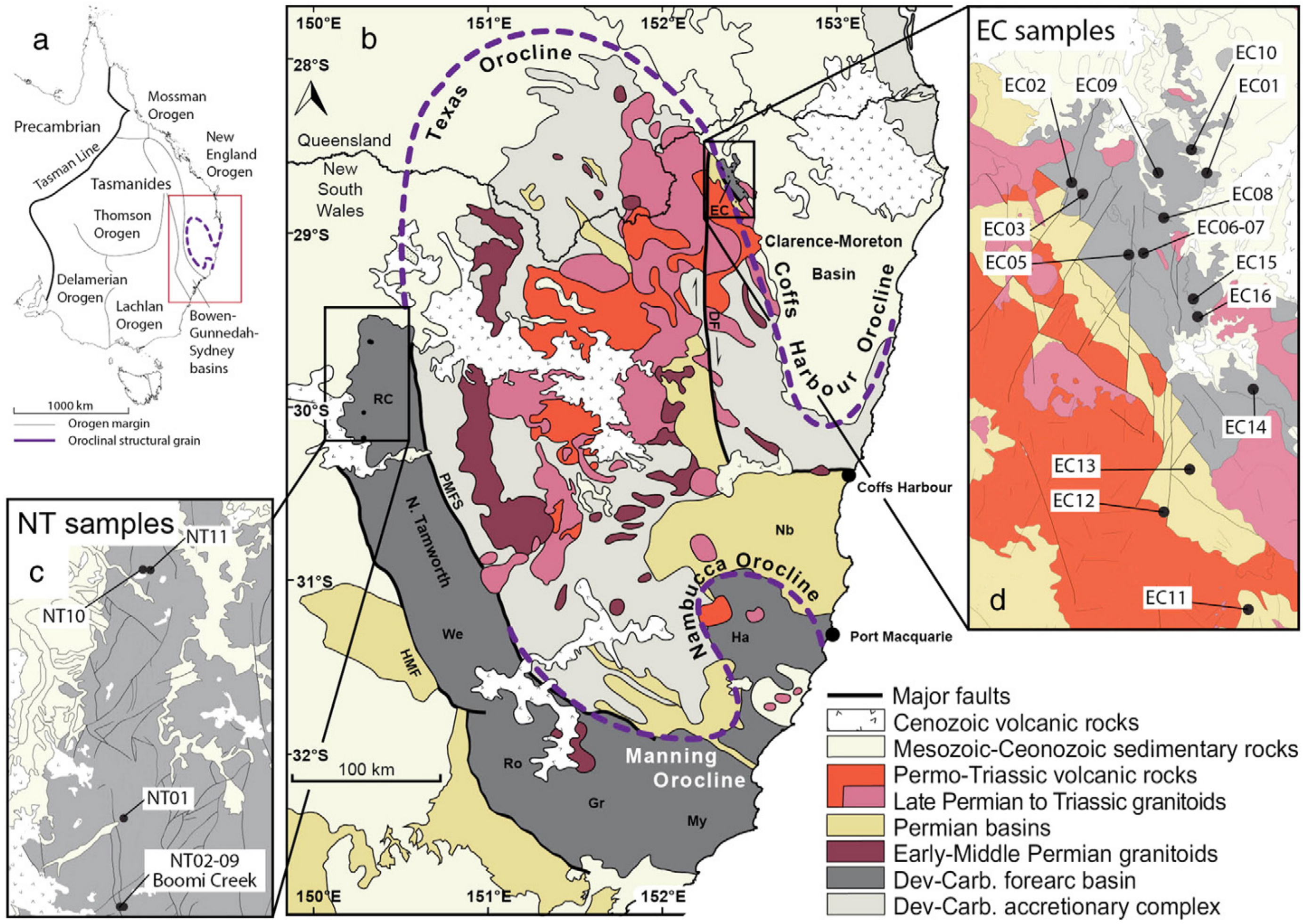

Fig. 1. (a) Location of the New England Orogen in the easternmost Tasmanides; (b) simplified tectonostratigraphic map of the southern New England Orogen. DF, Demon Fault; Ec, Emu Creek; Gr, Gresford; Ha, Hastings; Mb, Mount Barney; My, Myall; Na, Nandewar; Nb, Nambucca; PMFS, Peel Manning Fault System; HMF, Hunter–Mooki Fault; Rc, Rocky Creek; Ro, Rouchel; We, Werrie. (c) Geological map and sample locations in the northern Tamworth terrane. (d) Geological map and sample locations in the Emu Creek terrane.

rocks that are suggested to be correlative on both limbs of the Texas Orocline (Hoy et al., 2014), with the Emu Creek terrane exposed on the eastern limb, and the Rocky Creek Block (northernmost part of the Tamworth terrane) exposed on the western limb (Fig. 1b). The correlation between the Emu Creek and northern Tamworth terranes (Fig. 2) was based on similar biostratigraphic faunal assemblages, depositional environment, provenance, and geochronology (Hoy et al., 2014), but their spatial relations prior to oroclinal bending have not been established.

Paleomagnetic studies provide a powerful tool to reconstruct rotations of continents and terranes in general, and are thus of a particular importance for oroclinal structures (e.g., Johnston, 2001; Van der Voo, 2004; Weil et al., 2010; Gutiérrez-Alonso et al., 2012). In the southern NEO, Schmidt et al. (1994) studied the Kullatine Formation in the Hastings Block (Fig. 1b) and suggested 130° clockwise or 230° anticlockwise post-Serpukhovian rotation of this block with respect to the Australian craton. Paleomagnetic data from Visean rocks in the Rouchel, Gresford and Myall terranes (Fig. 1b) of the Manning Orocline (Geeve et al., 2002) were interpreted as post-Visean anticlockwise block rotations of 80°, 80° and 120°, respectively. These rotations are consistent with the hypothesised geometry of the southern segment of the oroclinal structure (e.g., Rosenbaum, 2012b; Li and Rosenbaum, 2014). However, Cawood et al. (2011) have proposed a different kinematic model and demonstrated that such large apparent rotations could partly be explained by long distance movements of these blocks in medium or high latitudes in a way suggested by Cox (1980) and Debiche et al. (1987) for terranes in western North America.

The aim of this paper is to refine previous kinematic reconstructions of the southern NEO (Cawood et al., 2011) using new paleomagnetic and geochronological data. We attempt to quantify vertical axis block rotations around the Texas Orocline, and to test whether such rotations are consistent with suggested models for oroclinal bending (e.g. Murray et al., 1987; Korsh and Harrington, 1987; Glen, 2005; Offler and Foster, 2008; Cawood et al., 2011; Glen and Roberts, 2012; Rosenbaum, 2012a; Rosenbaum et al., 2012; Shaanan et al., 2014). We present new paleomagnetic data from Carboniferous rocks in the Emu Creek and northern Tamworth terranes (Fig. 1), and U–Pb geochronological results that further refine stratigraphic relations in the northern Tamworth terrane.

2. Geology and sampling

The northern Tamworth terrane is commonly subdivided into two blocks, the Rocky Creek Block in the north and the Werrie Block in the south (Figs. 1 and 2). These blocks consist of predominantly Devonian and Carboniferous volcanic, volcaniclastic and sedimentary rocks, which were deposited in a forearc basin setting (Day et al., 1978). Previous paleomagnetic studies have been conducted on Visean to Kasimovian rocks from both the Rocky Creek and Werrie blocks

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